

Protective Measures Against Electric Shock

Mohamad Fouzi Takriti

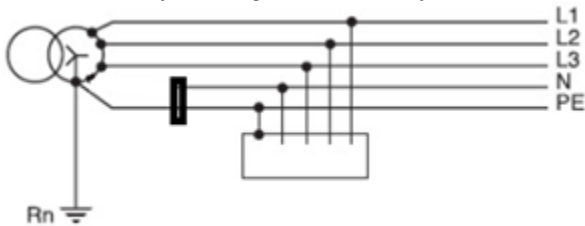
Abstract: Because it is a serious matter in electrical installations our Knowledge in protective measures should be always refreshed so we can save lives and properties from electrical hazards.

The basic names for low voltage systems:

We distinguish between the low-voltage systems types according to the grounding of both the source and the exposed conductive units in the system There are three main types: TN, TT, and IT

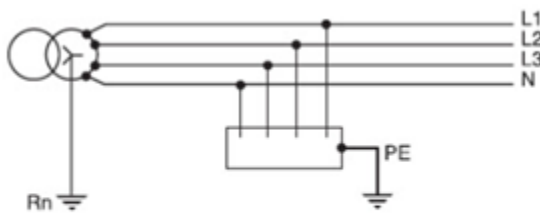
1-TN system:

In TN system the star point of the secondary windings of the source transformer is grounded and every exposed conductive part of any apparatus in the system is connected directly to the ground of the system.



2-TT system:

The difference here is in exposed conductive parts of any apparatus in the system is grounded separately from the system (i.e. has its own ground).



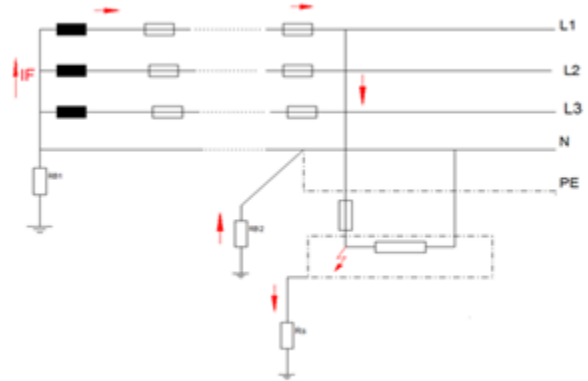
TT

3- IT system:

The secondary of the transformer her is not grounded but the exposed conductive parts of any apparatus in the system is grounded separately from the system (i.e. has its own ground).

Terms and definitions relating to protective measures:

- 1- An insulation fault is a faulty state in insulation.
- 2- A ground contact is an accidental electrical connection formed between a body (e.g. a metal housing) and live parts of electrical equipment.

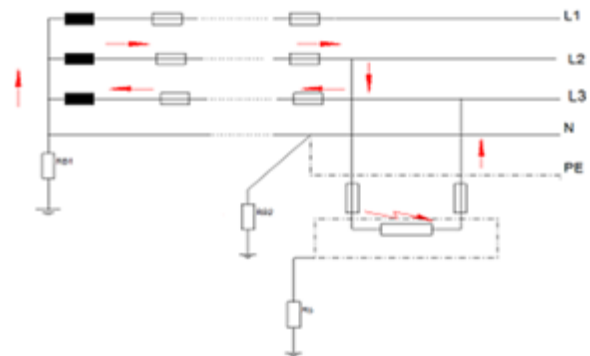


IF: fault current

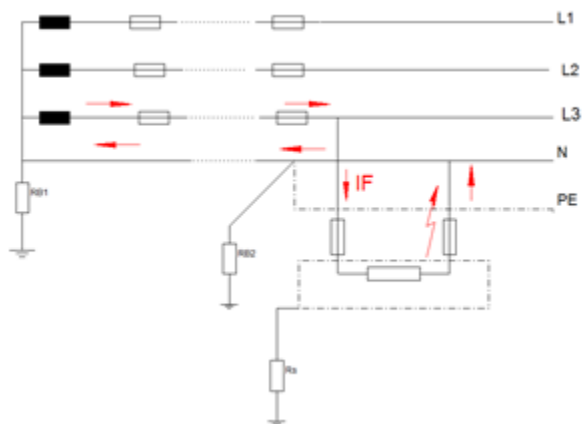
RB: Resistance of the service grounding electrode

RS: resistance of the protective grounding electrode

- 3- A short circuit is an accidental electrical connection between operationally live conductors, when there is no active resistance in the fault circuit.

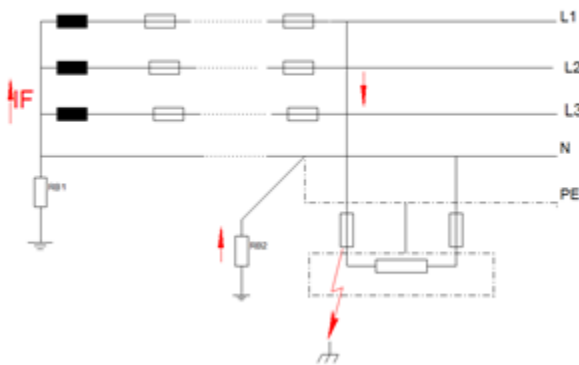


- 4- A conductor short-circuit is an accidental connection between operationally energized conductors when there is an active resistance



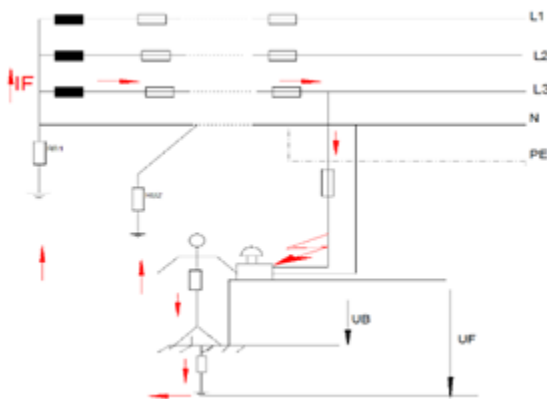
- Mohamad Fouzi Takriti is currently a specialized trainer in the Industrial Institute of The Public Authority for Applied Education and Training, Kuwait.
- E-mail: mfawzee@yahoo.com

5- A short-to-ground is any accidental electrical connection, including arcing, between an outer conductor or an insulated mid-point conductor and ground or grounded components



- 6- A fault voltage U_F : Is the accidental voltage occurring between physical objects and the reference ground.
- 7- A contact voltage U_B : is the fault voltage which can be bridged by a human body.
- 8- A fault current I_F : is the current which flows because of an insulation fault.
- 9- A leakage current: is the current which during normal operation flows from active parts of electrical equipment via normal undamaged insulation to non-active parts electrically connected to the mid-point conductor or to ground.

This illustration explains points 6-7-8



protection classes for electrical equipment

Class	Description	Example
Protection class I	Protective measure using protective conductor symbol	Equipment with metal housing e.g. electric motor
Protection class II	shockproof insulation symbol	Equipment with plastic casing e.g. domestic appliance
Protection class III	Protective low voltage symbol	Equipment with a rated voltage up to 42 v or 6 V e.g. electrical hand lamps

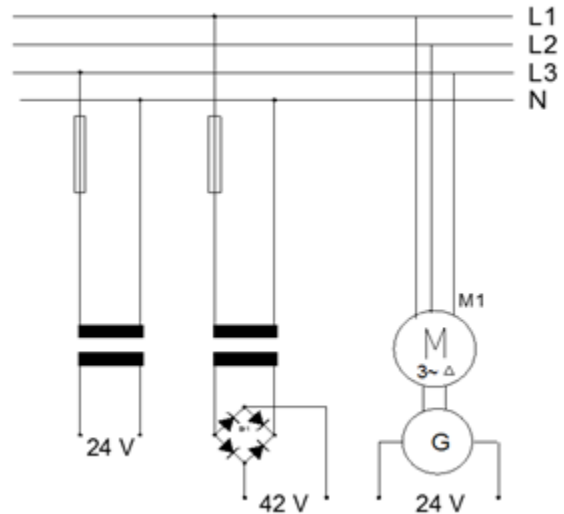
Measures of protection against direct or indirect contact:

1- Protection through Protective Extra-Low Voltage PELV:

This is used in circuits which not having special protective conductor, and for this purpose we use:

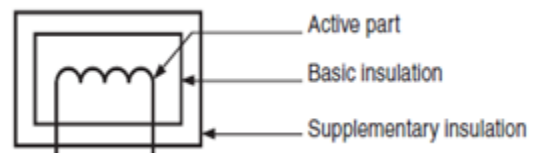
- Safety transformer
- Motor generator with insulated windings
- Electrochemical supply (e.g. battery)
- Electronic power supply unit with protected output

In this case the output voltage will be 42, 24, or 12 volts



2- Insulation protection:

Here appliances are referred to having “double insulation and No conductive parts of the appliance will be connected to a protective conductor.



3- Protective Measures relying on automatic disconnection

This can be used in direct and indirect contact for the most common TN and TT systems

3-1 – Automatic disconnection for TN system:

To ensure that any insulation fault (full ground contact) will cause the circuit to be opened by over current protective devices or RCDs (Residual Current Devices), circuit-breaker or fuses.

In this case the earth fault current will be:

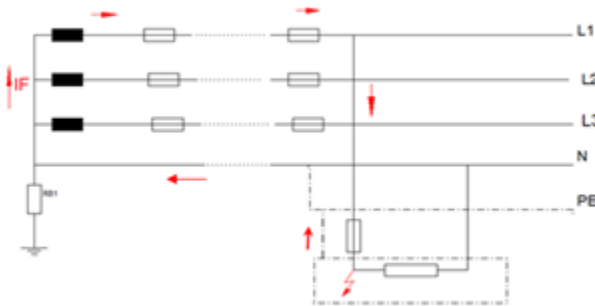
Where: U_E = the nominal phase to neutral voltage
 Z_{Sch} = the earth – fault current loop impedance

Example:

The case number 2 of the terms (ground contact):

Dennis Neitzel. Electrical Safety Handbook, Second Edition. McGraw-Hill, Inc. 2000

[4]. Mastrullo, Kenneth G., Jones, Ray A., Jones, Jane G., The Electrical Safety Program Book, National Fire Protection Association, Inc., Quincy, MA., 2003.



$$Z_c = Z_T + Z_L + Z_B + Z_U$$

(Z_T = Active impedance component of transformer winding

Z_L = impedance of the outer conductor

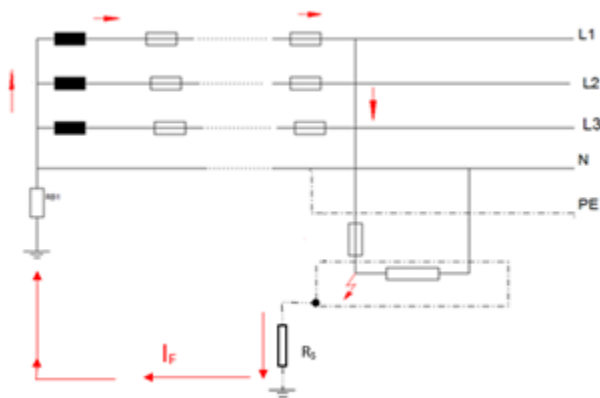
Z_B = service grounding impedance

Z_U = contact impedance)

By calculating I_F we can determine the instantaneous magnetic trip unit adjustment of the circuit-breaker.

3-2 – Automatic disconnection for TT system:

After an insulation fault, the protective grounding in TT system causes the fault current to flow from the grounded housing of an electrical appliance via the service grounding point through the ground to the grounding point of the transformer.



Where: R_s is the resistance of the protective grounding electrode for the installation.

$I_{\Delta n}$ is the rated residual operating current of the RCD

For work site and agricultural premises, the value of: 50 V is replaced by 25 V.

Conclusion:

Because of the serious effects due to the electric shock like: disturbances of heart, nervous paralysis, muscular paralysis, or others. It very important enhance our knowledge of the protective measures against the electric shock.

References:

[1]. EIG – F – Protection – electric – shock
 [2]. Siemens (protection against electric shock)
 [3]. Cadick, John, Mary Capelli-Schellpfeffer, and

Schneider Electric - Electrical installation guide 2007. F - Protection against electric shock. 1 General. 1.2 Protection against electric shock. The fundamental rule of protection against electric shock is provided by the document IEC 61140 which covers both electrical installations and electrical equipment. This protective measure depends on two fundamental requirements: b The earthing of all exposed-conductive-parts of electrical equipment in the installation and the constitution of an equipotential bonding network b Automatic disconnection of the supply of the section of the installation concerned, in such a way that the touch-voltage/time safety requirements are respected for any level of touch voltage U_c . The basic measures of protection against electric shock should be aimed at reliable isolation for a sufficiently long time. They include: rods (insulating); voltage indicators; stairs (insulating). Some security methods apply additionally. But they can be used only in conjunction with the main ones. Protective zeroing is the electrical connection of the open conductive parts of the electrical installation, which may be under voltage due to a short circuit. And what is equalization of potentials? This is the connection of parts conducting a current to equalize their potentials. This term is often used by electricians. Equalization of potentials is directly reducing the potential difference on the surface using protective conductors installed in the ground and connected to the grounding device.